Academic Journal of Engineering and Technology Science
ISSN 2616-5767 Vol. 2, Issue 1: 144-152, DOI: 10.25236/AJETS.020026

Container Terminal Handling Technology and Its Development

Hanfeng Li*, Yuhao Lu

College of Transportation, Shanghai Maritime University, Shanghai 201306, China
**Corresponding author e-mail: 761006059@qq.com*

ABSTRACT. *With the completion and operation of Yangshan Deepwater Terminal Phase IV, the fully automated container terminal has formally begun to enter the public's vision. As an extremely important part of container handling and transportation, handing technology has also been deeply considered and studied by many scholars. In order to grasp the direction of handing processes of automation container terminal, based on discussing the application status and advantages and disadvantages of the existing traditional and automated container terminal process system, this paper analyses the development trend of automated container handling technology in China ,according to the development of automated lock and disassembly device, remote control of quayside bridge, intelligent driving, new energy, automated tire crane and other equipment technology.*

KEYWORDS: *automation technology, container terminal, handing process*

1. Introduction

Since the 21st century, container transportation has been developing rapidly all over the world with its advantages of high loading and unloading efficiency and less freight loss. In order to adapt to the rapid development of container transportation, container ships begin to become large-scale and container terminals begin to become automated[1]. In order to shorten the berthing time of ships and reduce the cost of single container, all ports have made active explorations in handling technology. The so-called handling technology refers to the method and procedure of loading and unloading and handling cargo in a port. The cargo is loaded and unloaded according to certain operating processes and principles (taking into account the conditions of the port, cargo types, means of transport and handling equipment, time, cost and benefits). The biggest advantage of container terminal over general cargo terminal is its high efficiency, and handling technology is the guarantee of high efficiency of wharf operation.

ISSN 2616-5767 Vol. 2, Issue 1: 144-152, DOI: 10.25236/AJETS.020026

2. Current status of China's container terminal handling technology

Nowadays, China's port container handling technology is at a stage of development, and there are many problems. Some ports have already experienced the difficulty of adapting to the market demand for transportation capacity, which not only affects the development of the port, but also affects the construction of other fields. There is a big gap between China and developed countries in terms of container handling technology and management. This gap has widened with the economic development and the external competition pressure of container terminals, and it is gradually unable to meet the needs of future container transportation. Only rationally improving the port technology and optimizing scientific management can we further improve the container handling technology of the port, improve the efficiency of container terminal handing operations, and reduce operating costs to obtain considerable profits.

China's container terminals are in a state of coexistence between a traditional container terminal and an automated container terminal. For traditional container terminals, the usual handing systems are: chassis system, straddle system, tire-type gantry crane system, rail-mounted container gantry crane system, straddle carrier - gantry crane system, etc; and the automated handing system of container terminal is mainly composed of three operations: wharf handling, yard handing and horizontal transport of cargo in port which is key to form different automation handing processes. At present, the horizontal transportation equipment between the terminal and the yard is equipped with three types: automatic guided transport vehicles (AGV), straddle carriers and trucks. Therefore, the following three typical process systems are gradually formed: shore bridge + AGV + automatic track crane system , shore bridge + straddle carrier + automatic track hoist system, shore bridge + set card + automated track hoist system.

2.1 All kinds of advantages and disadvantages of the traditional Container Terminal Handling Technology

Chassis system: suitable for ports with small container throughput and large venues; most suitable for door-to-door transportation. The main advantages are fewer links, which can be directly landed; the wheel pressure is small; the organization is simple, the personnel requirements are low; no complicated equipment is needed. At the same time, the shortcomings are also obvious, occupying a large area, low utilization rate of the site; large amount of chassis vehicles; not easy to achieve automation; frequent maintenance.

Straddle-car system: It is suitable for ports with large import volume and small export volume. The main advantages are that there is a multi-function, the link is reduced; the maneuver is flexible, the efficiency is improved; the balance is easy to be balanced; the utilization rate of the yard is high. The main shortcomings are complicated structure and high failure rate; large wheel pressure, large body, and operation assistant; difficulty in stacking the site; high initial investment.

ISSN 2616-5767 Vol. 2, Issue 1: 144-152, DOI: 10.25236/AJETS.020026

Tire type gantry crane system: The main advantages are high site utilization rate; small yard pavement cost; simple equipment, low operation requirements; low container damage rate; small footprint, cross-box area; easy to automate. The main shortcomings are that it is more time-consuming to work across the box area; the rate of lodging is higher; the card needs to be equipped with more links; the higher initial investment; the higher energy consumption.

Rail-mounted container gantry crane system: main advantages are high site utilization; simple structure, high reliability container gantry crane system; convenient maintenance, low cost; electric drive, energy saving; easy to achieve automation. The main disadvantages are poor mobility; it is difficult to carry the box and reverse the box; high initial investment.

Straddle carrier - gantry crane system:

(1) Loading and unloading at the ship's edge is undertaken by the portainers.

(2) The horizontal transportation, stacking and delivery of imported containers are carried out by the straddle carrier.

(3) The horizontal transportation between the freight yard of the export box and the front edge of the terminal is completed by the container semi-trailer, and the loading and unloading and stacking of the freight yard are completed by the rail-type gantry crane.

Because the hybrid system can give full play to the characteristics of various machinery, and to avoid weaknesses, the system is more reasonable and perfect. At present, many terminals in the world have adopted this scheme.

2.2 Main handling equipments and handling technology of container terminal in China

The new 40-foot high-efficiency quayside container crane successfully developed by Shanghai Zhenhua Heavy Industry Co.,Ltd which can lift two 40 ft or four 20 ft boxes at the same time. This new dual 40 ft quayside container crane increases the handing efficiency by more than 50%. Later, double 40 ft and double dolly quayside container crane was developed, which combines the advantages of a dual 40 ft and double dolly quayside container crane and overcomes the shortcomings of both. In theory, the new double 40 ft and double dolly quayside container crane can handle up to 90-100 natural boxes per hour. The emergence of a large number of high-efficiency quayside container cranes has greatly improved the service level of the port, which has ensured the efficiency of high-level loading and unloading ships. At the same time, new requirements have been put forward for various aspects of the handing process system, such as horizontal transportation, yard handing equipment and stacking plan. The efficient handing process solution adapted to the efficient quayside container crane is applied.

ISSN 2616-5767 Vol. 2, Issue 1: 144-152, DOI: 10.25236/AJETS.020026

2.2.1 Quayside container crane + AGV + automatic container gantry crane

The horizontal transportation between the terminal and the yard of the process system adopts the unmanned AGV. Most of the dock handing operations use double dolly quayside container cranes, and the yard operations use automatic track cranes. The representative terminals are Rotterdam ECT terminal, Hamburg CTA terminal, Rotterdam Euromax terminal, Maasvlakte II terminal and RWG terminal. And China's completed Xiamen Yuanhai, Qingdao Qianwan Phase IV and Shanghai Yangshan Phase IV are also adopted this handing system. Among them, four automatic terminal are built in different periods in the Port of Rotterdam which represent the development process of the handing process system. According to the construction time and technical characteristics, it can be divided into three generations. [2]

(1) The first generation: ECT terminal is the first generation of automated container terminals using this type of process system, which realizes the automation of horizontal transportation and yard handingg, greatly reduces labor dependency and labor cost, and has an epoch-making effect on the technical development of container terminals. The terminal handing preocess adopts a single quayside container crane, cab operation; the horizontal transportation adopts the AGV driven by the diesel internal combustion engine, and the initial running speed is limited to 3 ms; the vertical docking of the yard is arranged, the automatic rail container gantry crane is used for handing operations, and one rack area is arranged for each box device. The work area of the external collection card delivery box is set outside the automated yard, and the manual driving is used for the straddle carrier operation. The handing area of AGV on the dock is located in the frame of the quayside container crane. The handing area of the yard is located at the end of the box. The AGV does not enter the yard. The AGV and the yard rail cranes are dispatched and managed by the terminal control room to realize automatic handing operations. Restricted by the level of computer technology, information processing and communication technology at that time, although the automation system realized unmanned and automated operation, the level of intelligence and informationization was insufficient, resulting in its horizontal handling efficiency and operating efficiency being lower than that of conventional container terminals; The handing area of the AGV is located in the rail of quayside container crane. All AGV must be turned into the exit frame of quayside container crane at the end of the berth. The route is fixed and the redundancy is small, which restricts the overall handing efficiency of the wharf. At the same time, it is limited by the AGV ring working channel. The free scheduling of quayside container cranes between adjacent berths is also restricted.

(2) The second generation: the Euromax terminal, which was completed and put into operation in 2008, is the representative of the second generation of automated terminals using this type of handing system. The terminal is optimized in forms of quayside container crane, process layout and horizontal transportation which makes the overall process level and handling efficiency of automation terminal improved . Wharf loading and unloading vessels use double dolly quayside container crane, the main trolley is operated by driver, the auxiliary trolley is automatic operated, and the

ISSN 2616-5767 Vol. 2, Issue 1: 144-152, DOI: 10.25236/AJETS.020026

automatic handing is extended to the process of container terminal handing; the AGV adopts diesel power generation and electric drive, and the speed is increased to 6 m/s; the handing area of AGV is changed in the below of rear extension of the quayside container crane, so that the AGV can turn at any suitable place; the dispatching system adopts a more flexible and efficient dispatching pool decision-making framework, and the route can be driven according to the optimal path; two bins of the same specification are arranged in each bin area of the yard. The sea side end of the container is the handover area of AGV, and the land side end is the transfer area of truck. Compared with the ECT terminal, the automation operation is extended to the work of collecting the trucks, further reducing the labor cost; The work can be carried out at the same time, and the work efficiency of the busy side can be improved by the relay method.

(3) The third Generation: The third generation of automated terminals using this type of process system is represented by the Maasvlakte II and RWG terminals built in 2015. Compared with the Euromax terminal, the two terminals are further optimized in terms of technology, efficiency and environmental protection, mainly in the following: the terminal loading and unloading adopts a double 40 ft (12.2 m) double trolley shore bridge, and the main trolley adopts automatic + manual confirmation remote control. The sub-car adopts fully automated operation mode, and the efficiency and automation of the dock loading and unloading ship are further improved; the AGV power adopts the battery, which is more energy-saving and environmentally friendly; the AGV carrier platform has the lifting function, enabling the AGV to take the initiative to take the fixed container bracket. The box is unloaded, and there is no need to passively wait for the rail to hoist and unload the truck at the yard, which effectively improves the transport efficiency of the AGV.

2.2.2 Quayside container crane + straddle carrier + automatic container gantry crane

The horizontal transportation between the terminal and the yard of the process system adopts a straddle carrier. The terminal handing process uses a single quayside container crane operated by a driver, and the yard operation uses an automatic track crane. The yards are all arranged on the vertical dock shoreline. The straddle carrier and the outer rig are respectively handed over to the rail crane at both ends of the area of containers. Since the navigation and positioning accuracy of the straddle carrier is relatively low compared to the AGV, the automatic docks using the handing process system.In addition to individual terminals, mostly adopt a step-by-step automation strategy, that is, the recent horizontal transportation uses manual driving to ensure safe operation and efficiency.The automation of the yard operation is realized in the three links of the process system. After the relevant technology matured , the straddle carrier is upgraded to unmanned driving to realize the automation of horizontal transportation and yard operation. Its representative terminals are London Gateway Terminal, Spain's BEST Terminal, and DPW Terminal in Antwerp, Belgium.

ISSN 2616-5767 Vol. 2, Issue 1: 144-152, DOI: 10.25236/AJETS.020026

2.2.3 Quayside container crane + wharf truck + automatic container gantry crane

The process system is only positioned to realize the automation of the yard operation. And the terminal handing process adopts a single t a single quayside container crane, the horizontal transportation adopts the collecting card, the yard operation uses the rail crane with cantilever, the container is stacked in the rail, and the cantilever is the truck working lane. It is usually preferred to use a double cantilever rail crane to allow the inner and outer trucks to work under the cantilever on both sides. At present, the operation of the stacking container and the internal wharf truck in the field are fully automated, and the manual remote control mode is adopted for the external wharf trucks operation to ensure the safety of the operation. The yard is generally arranged parallel to the shoreline of the dock. The application of the process system is mainly concentrated in the Asian region where the labor cost is relatively low. The representative terminals are the Kaohsiung Gaoming Wharf and Evergreen Wharf in Taiwan, the DPworld Phase III terminal in Dubai, UAE, etc. The Shenzhen Mawan Star Ferry Terminal and Taicang are under construction in China. The process system was also adopted in the fourth phase of the container terminal.

There are also other handing process systems, such as s quayside container crane + AGV + automatic tire crane, quayside container crane + automated straddle carrier, quayside container crane + wharf truck + automated viaduct crane, etc., but because these process systems are to meet the specific projects with certain limitations, so they do not have the value of promotion, and have not been used in the subsequent construction of automated terminals.

3. Future development direction and trend of handing technology

3.1 The overall development direction of the future container handling technology system

Automation and intelligence: Automated and intelligent container handling technology is an important direction for the future development of the container industry. Through advanced technology and equipment, work can be done through machines, thus reducing manual use. The handling technology of China's port containers should be developed in this direction, narrowing the gap with developed countries, improving its level of automation and intelligence, and bringing more technical and equipment support to the handing process.

Energy-saving and environmental protection: Energy-saving and environmental protection are also important directions for the development of container handling technology in the future. This is because the volume and weight of the containers are large, and a large amount of energy is consumed during the handing process, whether it is electrical energy or chemical energy. , will increase the operating costs of the port. With the development of society, people's demand for low-carbon environmental protection continues to increase. Only by improving the

ISSN 2616-5767 Vol. 2, Issue 1: 144-152, DOI: 10.25236/AJETS.020026

environmental performance and energy-saving performance of the handing process can it be more in line with the needs of society and promote harmonious development.

Specialization and versatility: Specialization and versatility are important requirements for the terminal handing process. Specialized docks can effectively improve the loading and unloading capacity and efficiency of containers, and can load a large number of containers into cargo ships in a short time. Or unloading cargo ships to improve the stability of logistics. At the same time, for different goods, it can also improve the multi-use ability and improve the transportation efficiency of goods.

Standardization and systemization: Energy-saving standardization and systemization are the key to ensure the mature development of container handling technology. Through this guidinosts, improve the level of modernization of the port, and thus bring greater help to other economic sectors.

Large-scale and high-efficiency: The huge container occupies a large proportion in the current loading and unlg concept, it can bring better help to the handing process of containers, improve the working efficiency of machinery, and reduce the port's efficiency. Operating coading. Therefore, it is necessary to constantly adapt to the reality that the container is bulky due to the large number of goods, and configure large-scale loading and unloading machinery at the dock to develop new types of loading and unloading containers. Improve the solid foundation for large-scale operations in containers.

3.2 The overall development direction of the future container handling technology system

3.2.1 Automatic lock pin disassembly device

At present, even in the automated terminal, the disassembly and assembly of the container lock pin during the container handing process still requires manual operation. Both RAM and ZPMC have been developing automatic locking and dismounting devices, and have achieved certain results. Since there is no uniform standard in the international construction of the lock pin, there are as many as 100 types in the 6 categories. At present, the automatic locking pin dismounting device cannot cover all of them, and manual auxiliary work is still needed when the locking pin is installed. However, with the gradual improvement and maturity of the automatic lock pin disassembly and assembly technology, it is a reality to equip the dock shore bridge with automatic lock pin disassembly and assembly equipment to further improve the automation of the terminal handing process [3].

3.2.2 Remote control technology of quayside container crane

The operation mode of the central dock of the automated terminal is from the initial manual operation to the operation of the main trolley driver and the sub-car automation. At present, it can realize the remote confirmation of the main trolley spreader in the precise alignment, boxing, opening and closing and lifting. In addition to the control, the other are automated operation modes, and the degree of

ISSN 2616-5767 Vol. 2, Issue 1: 144-152, DOI: 10.25236/AJETS.020026

automation is getting higher and higher, which further reduces the labor intensity of the equipment operators and improves the working environment. With the gradual maturity of remote control technology and improved work efficiency, this technology will be widely used in various types of container terminals.

3.2.3 Intelligent driving technology

The automation of horizontal transportation systems involves a large number of intelligent problems such as random routing decisions and traffic planning, which are the main influencing factors such as total investment and operational efficiency of automated terminals. The navigation of the AGV utilizes a magnetic nail embedded in a running area in a matrix manner, and the position information of the magnetic nail is read by the vehicle antenna to perform vehicle positioning, and is controlled by a computer to automatically travel along a prescribed guiding path, and the straddle carrier usually A navigation method using a differential global positioning system DGPS combined with a live positioning radar. The application of intelligent driving technology in AGV and straddle carrier will also make the navigation and control technology of the existing horizontal transportation leapfrog development, which will make the horizontal transportation link of the automated terminal achieve higher efficiency and lower cost on the existing basis. The operation, intelligent driving technology will bring new development opportunities to the automated container terminals.

3.2.4 New energy

In the development process of the automated terminal, horizontal transportation equipment is developing in the direction of energy conservation and environmental protection. The power of the AGV was driven by the original diesel internal combustion engine and diesel-powered electric drive to today's lithium battery, which makes the terminal operation non-polluting and zero-emission, while reducing the noise of the equipment and improving the working environment. At present, the use of LNG instead of diesel has been promoted and applied in major ports such as Shanghai and Ningbo, and has achieved good energy saving and emission reduction effects. LNG-powered technology has also been successfully tested on tire hoists. AGVs and straddle carriers using liquefied natural gas or gas and electric hybrids are also being developed.

3.2.5 Automated tire crane technology

Due to the different walking mechanism, compared with the track crane, the tire is easy to run when it is hoisted, and the tire is easily deformed. The height and the change will occur during the operation, and it is difficult to ensure the positioning accuracy of the target position. Therefore, it is relatively difficult to achieve automatic control and needs to be solved. A series of control technologies such as container stacking position distance detection, high-precision stacking control, and automatic movement and confirmation of large and small vehicles to the target position [4]. At present, relevant Chinese manufacturers and Shenzhen Port Chiwan Terminal and Shanghai Port Hudong Terminal are actively trying to automate tire cranes and have achieved certain results. Most of China's existing container terminals use tire cranes for yard operations. With the increase of labor costs and the

ISSN 2616-5767 Vol. 2, Issue 1: 144-152, DOI: 10.25236/AJETS.020026

gradual maturity of tire crane automation technology, the automation transformation of traditional container terminal yards will be an inevitable trend.

4. Conclusion

After years of technical accumulation, China's container terminal handing technology has gradually matured from continuous optimization, from the initial automated unmanned operation to intelligent, efficient, green, energy-saving and safe development, realizing the automated loading and unloading linked by the yard. The horizontal transport of cargo has gradually expanded to terminal loading and unloading. The automated container terminal can realize intelligent real-time control and dynamic dispatch of container loading and unloading, reduce the time of staying in the port, and effectively improve the efficiency of handing operations. With the development and application of intelligent driving technology and tire crane automation in the automotive industry, the automated container terminal will usher in new development opportunities.

References

[1] Li Jinlong.Development and Challenges of China's Automated Container Terminals [J]. China Port, 2016 (2): 17-20.
[2] Liu Shanping. Port Handling Technology (1st Edition) [M]. Beijing: China Communications Press, August 2010.
[3] Yang Rong,Yi Yingqiang.Design of New Type of Transfer Lock Disassembly Process for Automated Container Terminals [J]. Containerization, 2014, 25 (12): 33-36.
[4] Bo Haihu, Zhang Heng, Sun Yuanwei. Study on the Realization Method of RTG Remote Semi-automatic Operation Yard in Container Terminal [J]. Hoisting and Transportation Machinery, 2015 (4): 12-15.